CLAIMS

What is claimed is:

1. A positive active material for a rechargeable lithium battery comprising:

a core comprising a lithiated compound; and

at least two surface-treatment layers formed on said core, each of said surface-treatment layers comprising at least one compound selected from the group consisting of a coating-element-included hydroxide, a coating-element-included oxyhydroxide, a coating-element-included oxycarbonate, and a coating-element-included hydroxycarbonate,

wherein the coating element is selected from the group consisting of Mg, Al, Co, K, Na, Ca, Si, Ti, Sn, V, Ge, Ga, B, and As.

2. The positive active material according to claim 1, wherein:

the lithiated compound is selected from the group consisting of compounds represented by the formulas 1 to 13:

$Li_xMn_{1-y}M_yA_2$ (1)

$Li_xMn_{1-y}M_yO_{2-z}X_z$ (2)

$Li_xMn_2O_{4-z}X_z$ (3)

$Li_xMn_{2-y}M_yA_4$ (4)

$Li_xCo_{1-y}M_yA_2$ (5)

$Li_xCo_{1-y}M_yO_{2-z}X_z$ (6)

$Li_xNi_{1-y}M_yA_2$ (7)

$Li_xNi_{1-y}M_yO_{2-z}X_z$ (8)

$Li_xNi_{1-y}Co_yO_{2-z}X_z$ (9)

$Li_xNi_{1-y-z}Co_yM_zA_\alpha$ (10)

$Li_xNi_{1-y-z}Co_yM_zO_{2-\alpha}X_\alpha$ (11)

$Li_xNi_{1-y-z}Mn_yM_zA_\alpha$ (12)

$Li_xNi_{1-y-z}Mn_yM_zO_{2-\alpha}X_\alpha$ (13),

$0.95 \leq x \leq 1.1$, $0 \leq y \leq 0.5$, $0 \leq z \leq 0.5$, $0 \leq \alpha \leq 2$,

M is one selected from the group consisting of Al, Ni, Co, Mn, Cr, Fe, Mg, Sr, V, or rare earth elements,

A is selected from the group consisting of O, F, S and P, and

X is selected from the group consisting of F, S and P.

3. The positive active material according to claim 1, wherein said at least two surface-treatment layers comprise at least two coating elements selected from the group consisting of Mg, Al, Co, K, Na, Ca, Si, Ti, Sn, V, Ge, Ga, B, and As.

4. A method of preparing a positive active material for a rechargeable lithium battery comprising:

coating a lithiated compound with a coating liquid comprising at least two coating elements selected from the group consisting of Mg, Al, Co, K, Na, Ca, Si, Ti, Sn, V, Ge, Ga, B, and As; and

drying the coated compound.

5. The method according to claim 4, wherein:

the lithiated compound is selected from the group consisting of compounds represented by the formulas 1 to 13:,

$Li_xMn_{1-y}M_yA_2$ (1)

$Li_xMn_{1-y}M_yO_{2-z}X_z$ (2)

$Li_xMn_{2-y}M_yA_4$ (4)

$Li_xCo_{1-y}M_yA_2$ (5)

$Li_xCo_{1-y}M_yO_{2-z}X_z$ (6)

$Li_xNi_{1-y}M_yA_2$ (7)

$Li_xNi_{1-y}M_yO_{2-z}X_z$ (8)

$Li_xNi_{1-y}Co_yO_{2-z}X_z$ (9)

$Li_xNi_{1-y-z}Co_yM_zA_\alpha$ (10)

$Li_xNi_{1-y-z}Co_yM_zO_{2-\alpha}X_\alpha$ (11)

$Li_xNi_{1-y-z}Mn_yM_zA_\alpha$ (12)

$Li_xNi_{1-y-z}Mn_yM_zO_{2-\alpha}X_\alpha$ (13),

$0.95 \leq x \leq 1.1$, $0 \leq y \leq 0.5$, $0 \leq z \leq 0.5$, $0 \leq \alpha \leq 2$,

M is one selected from the group consisting of Al, Ni, Co, Mn, Cr, Fe, Mg, Sr, V, or rare earth elements,

A is selected from the group consisting of O, F, S and P, and

X is selected from the group consisting of F, S and P.

6. The method according to claim 5, wherein said drying the coated compound is performed at a temperature ranging from room temperature to 200°C for 1 to 24 hours.

7. The method according to claim 5, wherein said coating the lithiated compound comprises mixing the lithiated compound with the coating liquid while heating the lithiated compound and coating liquid at an increasing temperature.

8. The method according to claim 7, wherein said coating comprises mixing the lithiated compound with the coating liquid under one of a vacuum condition and a condition of injecting blowing gas while increasing the temperature.

9. The method according to claim 5, wherein said coating and said drying comprise:

first-coating the lithiated compound with the coating liquid comprising at least two coating elements selected from the group consisting of Mg, Al, Co, K, Na, Ca, Si, Ti, Sn, V, Ge, Ga, B, and As,

first-drying the first-coated lithiated compound to provide a first surface-treatment layer on a surface of the lithiated compound,

second-coating the first surface-treatment-formed lithiated compound with another coating liquid comprising at least two coating elements selected from the group consisting of Mg, Al, Co, K, Na, Ca, Si, Ti, Sn, V, Ge, Ga, B, and As, and

second-drying the second-coated lithiated compound to provide a second surface-treatment layer on the first surface-treatment layer of the lithiated compound;

10. The method according to claim 5, wherein said coating and said drying comprise using at least three kinds of coating liquids, the coating liquids comprising at least one coating element selected from the group consisting of Mg, Al, Co, K, Na, Ca, Si, Ti, Sn, V, Ge, Ga, B, and As.

11. A positive active material for a rechargeable lithium battery comprising:

a core comprising a lithiated compound;

a first surface-treatment layer formed on said core, said first surface-treatment layer comprising at least one compound selected from the group consisting of an Al-included hydroxide, an Al-included oxyhydroxide, an Al-included oxycarbonate, and an Al-included hydroxycarbonate; and

a second surface-treatment layer formed on said first surface-treatment layer, said second surface-treatment layer comprising at least one compound selected from the group consisting of an Si-included hydroxide, an Si-included oxyhydroxide, an Si-included oxycarbonate, and an Si-included hydroxycarbonate.

12. A method of fabricating a positive active material for a rechargeable lithium battery comprising:

coating a lithium-cobalt based compound with a first coating liquid comprising Al to form a first coating;

coating the first coating with a second coating liquid comprising Si; and

drying the lithium-cobalt based compound coated with the first and second coatings at a temperature ranging from room temperature to 200°C for 1 to 24 hours.

13. The method according to claim 12, wherein said coating the lithium-cobalt based compound with the first and/or second coating liquid and said drying comprises mixing the lithium-cobalt based compound with the first and/or second coating liquid while heating the lithium-cobalt based compound and the first and/or second coating liquid by increasing the temperature.

14. The method according to claim 13, wherein the mixing the lithium-cobalt based compound with the first and/or second coating liquid comprises mixing under one of a vacuum condition and a condition of injecting blowing gas while increasing the temperature.

15. A positive active material for a rechargeable lithium battery, comprising:

a core comprising a lithium-cobalt based compound;

a first surface-treatment layer formed on said core, said first surface-treatment layer comprising at least one compound selected from the group consisting of an Si-included hydroxide, an Si-included oxyhydroxide, an Si-included oxycarbonate, and an Si-included hydroxycarbonate; and

a second surface-treatment layer formed on said first surface-treatment layer, said second surface-treatment layer comprising at least one compound selected from the group consisting of an Al-included hydroxide, an Al-included oxyhydroxide, an Al-included oxycarbonate, and an Al-included hydroxycarbonate.

16. A method of fabricating a positive active material for a rechargeable lithium battery comprising:

coating a lithium-cobalt based compound with a first coating liquid comprising Si to form a first coating;

coating the first coating with a second coating liquid comprising Al to form a second coating; and

drying the lithium-cobalt based compound coated with the first and second coatings at a temperature ranging from room temperature to 200°C for 1 to 24 hours.

17. The method according to claim 16, wherein said coating the lithium-cobalt based compound with the first and/or second coating liquid is performed by mixing the lithium-cobalt based compound with the first and/or second coating liquid while increasing the temperature.

18. The method according to claim 17, wherein the mixing the lithium-cobalt based compound with the first and/or second coating liquid comprises mixing under one of a vacuum condition and a condition of injecting blowing gas and increasing the temperature.

18. The method according to claim 17, wherein the mixing the lithium-cobalt based compound with the first and/or second coating liquid comprises mixing under one of a vacuum condition and a condition of injecting blowing gas and increasing the temperature.

19. A method of preparing a positive active material for use in a lithium battery, comprising:

mixing a lithiated compound with first and second compounds while increasing a temperature during said mixing to form a surface treatment layer including the first and second compounds on the lithiated compound, the first and second compounds comprising corresponding first and second coating elements selected from the group consisting of Mg, Al, Co, K, Na, Ca, Si, Ti, Sn, V, Ge, Ga, B, and As.

20. The method of claim 19, wherein said mixing comprises heating to form a layer comprising mainly a first or second coating-element including hydroxide, oxyhydroxide, oxycarbonate, hydroxycarbonate, and/or a mixture thereof.

21. The method of claim 19, wherein said mixing comprises:

mixing the lithiated compound with the first compound to form a first coating layer on the lithiated compound, and

mixing the lithiated compound having the first coating layer with the second compound to form a second coating layer on the first coating layer.

22. The method of claim 19, further comprising blowing a gas through the lithiated compound during said mixing.

24. A lithium battery comprising:

a positive electrode comprising a coated lithiated compound, the coating comprising a surface treatment layer comprising first and second compounds, the first and second compounds comprising corresponding first and second coating elements selected from the group consisting of Mg, Al, Co, K, Na, Ca, Si, Ti, Sn, V, Ge, Ga, B, and As;

a negative electrode comprising a material to reversibly intercalate lithium ions; and

a separator and an electrolyte disposed between said first and second electrodes.

25. The lithium battery of claim 24, wherein the surface treatment layer comprises a first coating layer of the first compound and a second coating layer of the second compound.

26. The lithium battery of claim 24, wherein the surface treatment layer is formed by drying the first and second compounds to form a layer comprising mainly a first or second coating-element including hydroxide, oxyhydroxide, oxycarbonate, hydroxycarbonate, and/or a mixture thereof.